§3. Developments of Reduced Activation Ferritic/Martensitic Steels for Advanced Blanket Systems

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Reduced activation ferritic/martensitic steels (RAFs) have attracted attention as a means of simplifying the special waste storage of the highly radioactive blanket and first-wall structures from fusion reactors after service.

From the viewpoint of decreasing components such as molybdenum, niobium and nickel (principal alloying elements in conventional Cr-Mo steels) that transmutes to long-lived radioactive nuclides upon irradiation with 14 MeV high-energy neutrons in D-T fusion reactors, niobium and nickel must be severely restricted and molybdenum is replaced with other components such as tungsten.

One of the RAFs, it was reported that JLF-1 (9Cr-2W-V, Ta steel) has been developed and proven to have good resistance against high-fluence neutron irradiation.

Recently, in order to achieve higher energy conversion efficiency by using RAFs at elevated temperatures in advanced blanket systems, JLS-series (9Cr-xW-V, Ta; x = 2.5, 3.0 and 3.5) and JLF-OD (Oxide Dispersion Strengthen alloy based on JLF-1) have been prepared. In the steels, improved high temperature mechanical properties were intended by increasing tungsten contents and dispersion of Y_2O_3.

In the present work, high temperature mechanical properties of JLF-1, JLS-series and JLF-OD were characterized to obtain fundamental comprehension of correlations between high temperature mechanical properties and microstructural features.

Microstructural observations were performed by means of transmission electron microscopy (TEM) with energy dispersive X-ray spectrometry (EDS). Precipitation morphology was examined in detail, because precipitates transformation and/or its coarsening correspond with degradation creep property.

Fig. 1. shows the results of creep rupture tests with Larson-Miller parameter on JLF-1 and JLS-series. Creep properties were improved with increasing tungsten content.

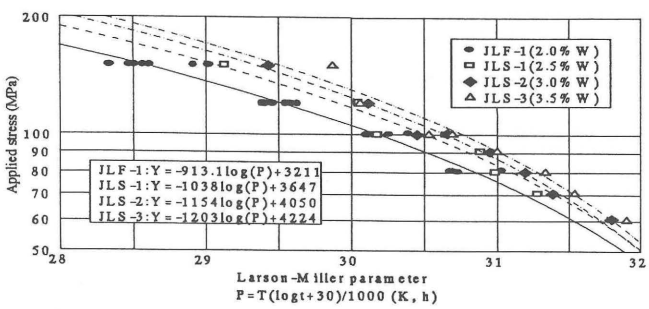

Fig. 1 Creep proprties with Larson-Miller parameter

Fig. 2. shows the weight percentage of precipitates of creep ruptured specimens.

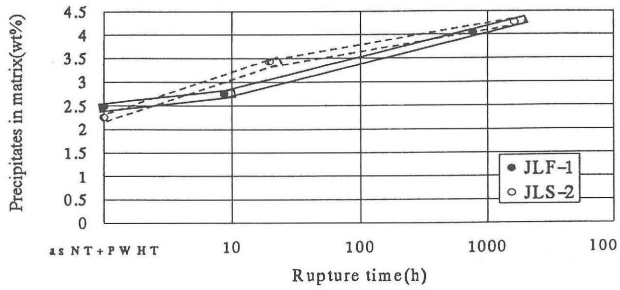

Fig.2. The weight percentage of precipitates of creep ruptured specimens

From the result, correlations between and creep properties and microstructural features were as follows.

1. Precipitation hardening effects on the improvement of creep properties efficiently in short rupture time, because of inhibiting dislocations from moving.
2. Solid solution hardening by dissolved tungsten in the matrix is dominantly to develop creep properties in long rupture time.

Fig. 3. shows the hardness of JLF-1 and JLF-OD at elevated temperatures.

JLF-OD A was performed normalizing, furnace cooling and tempering. On the other hand, JLF-OD B was performed normalizing, air cooling and tempering.

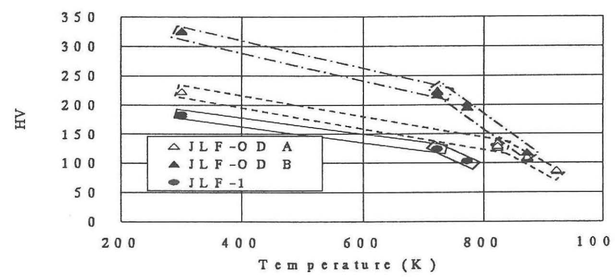

Fig. 3. Hardnesses at elevated temperatures of JLF-1 and JLF-OD

From the results, JLF-OD has better high temperature mechanical properties than JLF-1.It can be seen that difference between the hardness of JLF-OD B has better properties than A. From microstructural observations with TEM on JLF-OD, JLF-OD B has finer distribution of Y_2O_3 than A.

So, the high temperature mechanical property of JLF-OD will be improved by more suitable heat treatments with finer distribution of oxides.

Reference

1. Sakasegawa, H., ASTM STP 1405 (now printing)